American POTATO JOURNAL

Volume 36 *October 1959* *Number 10*

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Official Publication of

THE POTATO ASSOCIATION OF AMERICA

NEW BRUNSWICK, NEW JERSEY, U. S. A

American Potato Journal

PUBLISHED BY
THE POTATO ASSOCIATION OF AMERICA
NEW BRUNSWICK, N. J.

Price $4.00 per year in North America; $5.00 in other countries.
Not responsible for free replacement of non-delivered or damaged issues after 90 days.

Entered as second class matter at New Brunswick, N. J., March 14, 1942 under Act of March 3, 1879. Accepted for mailing at special rate of postage provided for in section 412, Act of February 28, 1925, authorized on March 14, 1928.

RECOVERY OF RECURRENT PARENT CHARACTERS FROM CROSSES OF *SOLANUM DEMISSUM* x *S. TUBEROSUM* IN SUCCESSIVE BACKCROSSES[1]

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Because of its late blight resistance, *S. demissum* has been used most extensively of the wild species for the improvement of the cultivated species. *S. tuberosum*. To combine late blight resistance with desirable economic characters of domestic varieties, a different *S. tuberosum* parent is usually employed for obtaining successive backcross generations. Reddick (12) advised against the use of the same parent clone twice in succession because of the decrease in vigor of the progenies. Bukasov (4) made a similar observation.

The first backcross (BC_1) generation plants may range in appearance from *S. tuberosum* to *S. demissum* according to Schmidt (14). Becker (1) found the means for leaflet shape, stem diameter, stolon length, number of tubers, immaturity and frost injury of four BC_1 progenies intermediate to those of the *S. tuberosum* and *S. demissum* parental progenies. Three of the four BC_1 progenies had mean cotyledon lengths smaller than the parents. Mean yields of the BC_1 progenies were equal to that of the *S. tuberosum* parent.

Kamaraz(6) observed that the F_1 yield was low and an increase in yield occurred in BC_2 and BC_3 progenies. Yields of backcrosses were lower than ordinary *S. tuberosum* crosses. Rudorf and Ross (13) and Toxopeus (15), however, found the yield of selected BC_3 and BC_4 clones often exceeded that of cultivated varieties.

Reddick (11, 12) noted that few BC_1 or BC_2 clones approach commercial varieties. Some of the BC_3 clones had the characteristics of *S. tuberosum*. In the BC_4 and BC_5 progenies there was no material increase in number of desirable plants. Occasionally, superior clones occur in early backcross generations. Gern (5) reported the release of a BC_2 clone as a variety. Black (2) and Koopman and Mastenbroek (7) suggested at least 3 backcross generations were necessary to eliminate undesirable properties of *S. demissum*. Similarly, in cereal crops, Briggs and Allard (3) noted the apparent recovery of recurrent parent characters by the BC_3.

To transfer the late blight resistance of *S. demissum* to two *S. tuberosum* parent clones, a backcross program was initiated. During the process of developing backcross progenies and sufficient clonal stock of individuals within progenies for satisfactory selection tests, a study was made on the rate of recovery of the recurrent parents in the absence of selection. A group of quantitatively inherited foliage and tuber characters

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[1]Accepted for publication November 28, 1958.
Paper number 3989 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station.

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were objectively measured. The results may serve as a basis for comparing the recovery of characters of the recurrent parent with selection for characters of the non-recurrent parent.

Materials and Methods

Two samples of *S. demissum*, PI 160221 and 161181 (hereafter designated as 50.3 and 50.1, respectively), were crossed with two *S. tuberosum* parent clones. *S. demissum*, 50.1, was crossed with an S_0 *S. tuberosum* parent, X528-170, which has been used extensively in a number of breeding programs and is a parent of at least two introduced varieties (9, 10). *S. demissum*, 50.3, was crossed with an S_3 *S. tuberosum* parent, Minn. 15-2-10-1-2. The latter is a derivative of a breeding line used successfully in the Minnesota program for the development of a number of superior parental clones and as a parent of one variety (8).

An F_1 plant from each of the two interspecific crosses was backcrossed to its respective *S. tuberosum* parent clone resulting in seed used to grow BC_1 progenies. The second backcross progenies to each of the two *S. tuberosum* parents were obtained by crossing BC_1 plants with their respective recurrent parents. BC_3 progenies to each of the two *S. tuberosum* parents, in turn, were obtained by crossing BC_2 plants with their respective recurrent parents.

Seedling progenies of the parents, their F_1 and three successive backcrosses to each of the two *S. tuberosum* recurrent parent clones were grown in the greenhouse at St. Paul, Minnesota. The progenies grown in the two series of hybrids will be given in results. Up to 56 plants were started of each progeny. Tubers obtained from the seedlings were used to produce the first clonal generation grown in the field at Castle Danger, Minnesota. Nine foliage and 3 tuber characters were studied in the seed propagated progenies, and 6 foliage and 2 tuber characters in the clonally propagated progenies. Each progeny of both seedlings and clones was grown in 4 plots of up to 14 plants each and they were distributed at random in each of the 4 blocks.

Plot values, obtained by averaging values of individual plants, were analyzed by analyses of variances. Progeny means, based on the average of plot values, were compared with the LSD_{05}. In each of the two series of hybrids, the F_1 and successive backcrosses have a lineal relation. Therefore, the linear trend of the F_1 and successive backcross generation means was tested by partitioning the progeny variance.

Experimental Results

The series of hybrids with the S_3 S. tuberosum parent clone, 15-2-10-1-2, as the recurrent parent.

The means of the parents, their F_1 and successive backcrosses to the S_3 *S. tuberosum* parent for foliage and tuber characters are summarized in table 1. The progenies, started from true seed, were grown in the greenhouse during fall and winter. The means of the self progeny of the recurrent parent, *S. tuberosum*, were greater than those of the non-recurrent parent, *S. demissum*, for cotyledon width, simple leaf number, and first leaf length and width; smaller for largest simple leaf length and

TABLE 1.—*Means for the parent, F_1 and successive backcrosses progenies to the S_3 S. tuberosum parent, 15-2-10-1-2: Progenies, first year from seed.*

Progeny	Cotyledons		Simple Leaves	First Leaf		Largest Simple leaf		Stem Length 75 days After Seeding	Mature Stem Length	Tuber Yield	Tuber Set	Weight of Largest Tuber
	Length	Width		Length	Width	Length	Width					
	mm.	mm.	number	mm.	mm.	mm.	mm.	cm.	cm.	grams	number	grams
P_1 *S. demissum* (50.3)	5.4	3.1	7.0	7.3	4.6	32.3	19.4	3.9	7.4	2.6	6.7	0.7
P_2 *S. tuberosum* (15-2-10-1-2)	5.1	4.3	15.5	8.6	6.7	17.6	12.8	2.7	5.8	1.9	2.7	0.8
F_1	8.9	5.3	8.8	11.2	7.9	39.1	25.3	4.2	6.1	5.3	5.8	1.5
BC_1	8.0	5.5	14.8	10.2	7.9	23.6	18.1	4.9	8.8	2.7	3.5	0.9
BC_2	6.8	5.2	14.5	9.0	6.8	19.5	15.3	3.3	5.6	2.1	3.4	0.8
BC_3†	6.2	4.6	15.0	8.8	6.7	18.6	14.4	3.0	5.7	2.3	3.3	0.9
LSD_{05}	0.9	0.6	2.5	1.2	0.8	4.3	3.1	1.3	2.7	0.7	1.2	0.2
Linear trend	**	**	*	**	**	**	**	**	N.S.	**	**	**

†Average of four progenies
*Significant
**Highly significant

width, yield and set of tubers; and equal for cotyledon length, stem length 75 days after seeding and at maturity, and weight of largest tuber. The means of the F_1 exceeded those of its parents for all characters studied except for simple leaf number, stem length measurements and tuber set. Highly significant negative linear trends from the F_1 toward the mean of the recurrent parent were obtained in successive backcross generations for all characters studied except for simple leaf number with a significant positive trend and mature stem length with no trend. Except for cotyledon length (significantly greater), the averages of the BC_3 progeny means were equal to those of the recurrent parent.

The response of the parent progenies for size of largest simple leaves and for tuberization was altered markedly by differences in day-length. A comparison of the means for length and width of largest simple leaf of the parents, F_1 and some backcross progenies grown under short and long days is given in table 2. Largest simple leaf size of *S. demissum* remained constant under both day-length conditions. The leaves of *S. tuberosum,* however, were more than twice as large under long than short days. The F_1 means were greater than either parent under short days and similar to *S. demissum* under long days. Backcross progenies responded as would be expected on the basis of parental behavior. With respect to tuberization, *S. demissum*—a short day plant, set tubers only under short days, contrasted to *S. tuberosum*—a long day plant, which set tubers under both short and long lays.

TABLE 2—*A comparison of means for length and width of largest simple leaf of progenies grown under contrasting daylengths.*

Progeny	Means in millimeters			
	Short days		Long days	
	Length	Width	Length	Width
P_1 *S. demissum* (50.3)	32.3	19.4	32.9	19.9
P_2 *S. tuberosum* (15-2-10-1-2)	17.6	12.8	43.9	34.5
F_1	39.1	25.3	31.5	23.0
BC_1	23.6	18.1	..	..
BC_2	19.5	15.3	43.5*	31.3*
BC_3	18.6**	14.4**	..	..
$LSD_{.05}$	4.3	3.1	5.3	3.6

*Average of three BC_2 progeny means
**Average of four BC_3 progeny means

Progenies grown the first year in the greenhouse from seed were propagated from tubers and grown in the field the second year. The means for foliage and tuber characters studied are summarized in table 3. The means of the two parents differed for all characters studied except weight of green vines. The overall hybrid vigor of the F_1 is suggested by generally higher means for foliage characters compared to its parents, particularly

TABLE 3.—*Means for the parents, F_1 and successive backcrosses to the S_3 S. tuberosum parent, 15-2-10-1-2: Progenies, second year from tubers.*

Progeny	Weight of green vines	Secondary branches	Length of longest leaf	Leaflets per leaf	Largest non-terminal leaflet Length	Largest non-terminal leaflet Width	Tuber Yield	Tuber Set
	lbs.	number	cm.	number	mm.	mm.	lbs.	number
P_1 *S. demissum* (50.3)	1.2	10.0	19	14	61	33	0	0
P_2 *S. tuberosum* (15-2-10-1-2)	0.9	5.7	27	18	90	51	0.4	1.8
F_1	3.1	14.3	28	22	92	58	0	0
BC_1	1.8	12.0	27	22	83	53	0.2	2.4
BC_2	1.1	8.0	27	20	81	52	0.4	2.5
BC_3*	1.0	7.4	27	23	83	54	0.6	3.4
$LSD_{.05}$	0.6	2.8	4	4	11	9	0.3	1.4
Linear trend	**	**	N.S.	N.S.	N.S.	N.S.	**	N.S.

*Average of four progenies
**Highly significant

with respect to weight of green vines in which the mean of the F_1 was 3 times as great as those of its parents. Like *S. demissum,* the F_1 failed to produce tubers under long days. Highly significant negative trends from the F_1 toward the mean of the recurrent parent were obtained in successive backcross generations for weight of green vines and number of secondary branches, and a highly significant positive trend for tuber yield. Except for higher means for number of leaflets per leaf and tuber set, the averages of the BC_3 progeny means were equal to those of the recurrent parent, *S. tuberosum.*

With respect to tuber set, both *S. demissum* and the F_1 had a potential for extremely high tuber set. Under field conditions these produced virtually a mat of branched stolens. It is suggested, had these progenies been exposed to a day-length favorable for tuberization prior to harvest, both would have produced a high set of tubers. The higher mean values for tuber set in backcross progenies may be interpreted as the result of genes continued from *S. demissum.*

The series of hybrids wih the S_0 S. tuberosum parent clone, X528-170, as the recurrent parent.

The means for the foliage and tuber characters of the parents, F_1 and successive backcross progenies involving the S_0 *S. tuberosum* parent, X528-170, as the recurrent parent are given in table 4. These progenies from true seed were grown in the greenhouse together with the series of hybrids with 15-2-10-1-2 as the recurrent parent, presented above. The two parents, *S. demissum* and *S. tuberosum,* differed from one another for all characters studied except for cotyledon length, first leaf length and width, and largest simple leaf width. The means of the F_1 exceeded those

TABLE 4.—*Means for the parent, F_1 and successive backcross progenies to the S_0 S. tuberosum parent, X528-170: Progenies, first year from seed.*

Progeny	Cotyledons Length	Cotyledons Width	Simple Leaves	First Leaf Length	First Leaf Width	Largest Simple leaf Length	Largest Simple leaf Width	Stem Length 75 days after Seeding	Mature Stem Length	Tuber Yield	Tuber Set	Weight of Largest Tuber
	mm.	mm.	number	mm.	mm.	mm.	mm.	cm.	cm.	grams	number	grams
P_1 *S. demissum* (50.1)	5.1	2.6	10.5	8.0	5.6	29.8	18.5	2.8	3.7	2.4	4.0	0.7
P_2 *S. tuberosum* (X528-170)	5.1	4.3	13.8	7.8	6.0	22.0	17.3	8.9	15.6	3.3	6.0	1.0
F_1	7.9	4.0	11.0	7.6	5.7	14.9	11.5	1.9	3.2	1.4	2.9	0.7
BC_1	7.0	4.2	15.0	7.3	5.9	19.8	15.5	4.8	8.8	2.7	3.9	0.8
BC_2†	6.1	4.2	15.1	8.3	6.4	21.1	17.2	4.9	8.9	2.8	4.0	1.1
BC_3††	5.3	3.8	13.7	8.1	6.4	21.1	16.5	5.5	10.7	2.9	3.8	1.2
$LSD_{.05}$	0.7	0.6	2.5	1.1	N.S.	4.2	3.1	1.4	3.1	0.9	1.1	0.3
Linear trend	**	N.S.	N.S.	N.S.	N.S.	**	**	**	**	**	N.S.	**

**Highly significant
†Average of three progenies
††Average of four progenies

of its parents only for cotyledon length; for the remaining characters, its means were equal to or smaller than those of its parents. The linear trend from the F_1 thru the BC_3 was negative only for cotyledon length; for largest simple leaf length and width, stem length 75 days after seeding and at maturity, tuber yield and weight of largest tuber, the linear trends were positive. The generation means of the BC_1 and BC_2 differed from those of the recurrent parent for 4 of the 12 characters studied, and for 3 of these 4 in the BC_3.

Progenies grown the first year in the greenhouse from true seed were propagated from tubers and grown in the field the second year together with the series of backcrosses to 15-2-10-1-2 given above. It will be seen in table 5 that the parents differed for size of largest non-terminal leaflets and tuber production. The F_1 means exceeded those of its parents only for length of longest leaf and leaflets per leaf. Neither the F_1 nor *S. demissum* produced tubers. Linear trends from the F_1 thru the BC_3 were negative for length of longest leaf and leaflets per leaf, and positive for yield and set of tubers. Three characters, length of longest leaf, tuber yield and set, differed from the recurrent parent in BC_1; one character, tuber yield, in the BC_2; and none in the BC_3.

TABLE 5.—*Means for the parents, F_1 and successive progenies to the S_0 S. tuberosum parent, X528-170: Progenies, second year from tubers.*

Progeny	Weight of green vines	Secondary branches	Length of longest leaf	Leaflets per leaf	Largest non-terminal leaflet Length	Largest non-terminal leaflet Width	Tuber Yield	Tuber Set
	lbs.	number	cm.	number	mm.	mm.	lbs.	number
P_1 *S. demissum* (50.1)	1.4	13.0	20	15	52	30	0	0
P_2 *S. tuberosum* (X528-170)	1.2	12.7	20	14	71	48	1.1	8.2
F_1	1.0	11.7	25	19	77	47	0	0
BC_1	1.5	12.3	24	16	72	46	0.3	2.2
BC_2†	1.0	10.8	20	13	69	48	0.6	5.4
BC_3††	1.5	12.8	21	14	72	47	1.0	6.7
$LSD_{.05}$	N.S.	N.S.	3	3	11	6	0.4	3.0
Linear trend	N.S.	N.S.	*	**	N.S.	N.S.	**	**

*Significant
**Highly significant
†Average of three progenies
††Average of four progenies

Comparison of the two series of hybrids and their parents.

Means for the seedling grown progeny of the two *S. demissum* parents (50.3 and 50.1), the two *S. tuberosum* parents (15-2-10-1-2 and X528-170), the two interspecific crosses (50.3 x 15-2-10-1-2 and 50.1 x X528-170), and the BC_3 to each of the *S. tuberosum* parents are given in table

TABLE 6.—*Means for the parent, F_1 and BC_3 progenies of the two series of hybrids: Progenies, first year grown from seed.*

Progeny	Cotyledons		Simple Leaves	First Leaf		Largest Simple Leaf		Stem Length 75 days after Seeding	Mature Stem Length	Tuber Yield	Tuber Set	Weight of Largest Tuber
	Length	Width		Length	Width	Length	Width					
	mm.	mm.	number	mm.	mm.	mm.	mm.	cm.	cm.	grams	number	grams
P_1 *S. demissum* (50.3)	5.4	3.1	7.0	7.3	4.6	32.3	19.4	3.9	7.4	2.6	6.7	0.7
P_1 *S. demissum* (50.1)	5.1	2.6	10.5	8.0	5.6	29.8	18.5	2.8	3.7	2.4	4.0	0.7
P_2 *S. tuberosum* (15-2-10-1-2)	5.1	4.3	15.5	8.6	6.7	17.6	12.8	2.7	5.8	1.9	2.7	0.8
P_2 *S. tuberosum* (X528-170)	5.1	4.3	13.8	7.8	6.0	22.0	17.3	8.9	15.6	3.3	6.0	1.0
F_1 50.3 x 15-2-10-1-2	8.9	5.3	8.8	11.2	7.9	39.1	25.3	4.2	6.1	5.3	5.8	1.5
F_1 50.1 x X528-170	7.9	4.0	11.0	7.6	5.7	14.9	11.5	1.9	3.2	1.4	2.9	0.7
BC_3 15-2-10-1-2, recurrent parent	6.2	4.6	15.0	8.8	6.7	18.6	14.4	3.0	5.7	2.3	3.3	0.9
BC_3 X528-170, recurrent parent	5.3	3.8	13.7	8.1	6.4	21.1	16.5	5.5	10.7	2.9	3.8	1.2

TABLE 7.—*Means for the parent, F_1 and BC_3 progenies of the two series of hybrids: Progenies, second year from tubers.*

Progeny	Weight of Green Vines	Secondary Branches	Length of Longest Leaf	Leaflets Per Leaf	Largest Non-terminal Leaflet Length	Largest Non-terminal Leaflet Width	Tuber Yield	Tuber Set
	lbs.	number	cm.	number	mm.	mm.	lbs.	number
P_1 *S. demissum* (50.3)	1.2	10.0	19	14	61	33	0	0
P_1 *S. demissum* (50.1)	1.4	13.0	20	15	52	30	0	0
P_2 *S. tuberosum* (15-2-10-1-2)	0.9	5.7	27	18	90	51	0.4	1.8
P_2 *S. tuberosum* (X528-170)	1.2	12.7	20	14	71	46	1.1	8.2
F_1 50.3 x 15-2-10-1-2	3.1	14.3	28	22	92	58	0	0
F_1 50.1 x X528-170	1.0	11.7	25	19	77	47	0	0
BC_3 15-2-10-1-2, recurrent parent	1.0	7.4	27	23	83	54	0.6	3.4
BC_3 X528-170, recurrent parent	1.5	12.8	21	14	72	47	1.0	6.7

6. Summarized data on their first clonally propagated progeny are shown in Table 7.

The progenies grown from seed of the 50.1 and 50.3 *S. demissum* parents were similar for most characters. Possible exceptions were in simple leaf number, stem-length measurements and tuber set. In the first clonal generation, means of 50.1 and 50.3 were similar for all characters studied except for slight differences in number of secondary branches and size of largest non-terminal leaflet.

The progenies of the two *S. tuberosum* parents, 15-2-10-1-2 and X528-170, differed from one another for a majority of the seedling characters studied. Substantial differences were obtained in size of largest leaf, stem-length measurements, and tuber characters (Table 6). In the first clonal generation, means differed for all characters studied except weight of green vines. Except for weight of green vines and number of secondary branches, the means for other foliage characters of 15-2-10-1-2 were higher, while yield and set of tubers were lower than for X528-170 (Table 7).

For seedling characters the means of the F_1, 50.3 x 15-2-10-1-2, were higher than those of the F_1, 50.1 x X528-170, except for a lower simple leaf number. In the first clonal generation, means of all foliage characters were higher for the F_1, 50.3 x 15-2-10-1-2 than for 50.1 x X528-170. The data suggest that in crosses with *S. demissum,* 15-2-10-1-2, an inbred parental clone, possessed combining ability superior to that of the non-inbred parental clone, X528-170.

For seedling characters, the highly significant trends obtained in successive generations backcrossed to 15-2-10-1-2 from the F_1 toward the recurrent parent were negative for all characters studied except for a positive trend for number of simple leaves and no trend for mature stem length. In successive generations backcrossed to X528-170, one character (length of cotyledons) had a highly significant negative trend, five had no observable trends, and six had highly significant positive trends. In the first clonal generation, successive generations backcrossed to 15-2-10-1-2 had negative trends for weight of green vines and number of secondary branches, a positive trend for tuber yield, and no discernible trends for five other characters. In the backcrosses to X528-170, trends were negative for length of longest leaf and number of leaflets per leaf, positive for tuber yield and tuber set, and insignificant for the four remaining characters. These results suggest that for a majority of characters successive generations backcrossed to 15-2-10-1-2 had progressive decreases from the F_1 to the recurrent parent while those to X528-170 had a reverse response.

In the seed grown generation, the averages of four BC_3 progenies with 15-2-10-1-2 as the recurrent parent, were higher for length and width of cotyledons, number of simple leaves, and length and width of first leaf, while for length and width of largest simple leaf, stem length measurements, and tuber characters, they were lower than the average of the four BC_3 progenies with X528-170 as the recurrent parent. In the first clonal generation, means of the BC_3 to 15-2-10-1-2 were higher than the BC_3 to X528-170 for length of longest leaf, leaflets per leaf, and length and width of largest non-terminal leaflet, and lower in weight of green vines, number of secondary branches, and yield and set of tubers. The differences obtained between the two series of BC_3 progenies in both seedling and clonally

propagated generations were similar to the differences of their respective recurrent parents.

The backcross progenies of two series of hybrids were readily distinguishable from one another in the field grown, clonally propagated generation. Extremes in appearance occurred in the BC_1 progenies; nevertheless, the distinctive foliage characters and flowering habit of the respective recurrent parents were apparent. Also, within the series of backcrosses to each of the two *S. tuberosum* parents, the BC_1 progenies were discernible from the BC_2 and likewise, the BC_2 from the BC_3; however, the latter were practically indistinguishable from the self progenies of their respective recurrent parents.

Discussion

The recovery rate of recurrent parent characters was essentially the same using either an inbred or non-inbred parent clone as the recurrent parent. Progenies with the distinctive plant and tuber characters of the recurrent parents were obtained by the BC_3. The results suggest that the rate of recovery of recurrent parent genes (or loss of non-recurrent parent genes) obtained in these interspecific backcrosses was similar to that normally expected in intraspecific backcrosses.

For the majority of characters studied, successive generations backcrossed to the inbred parent had progressive decreases in mean values from the F_1 toward the recurrent parent, while the reverse was obtained in successive generations backcrossed to the non-inbred parent. This difference may be due to a greater frequency of favorable genes contributed by the inbred parent resulting in higher F_1 values and in consequence greater differences between the F_1 and recurrent parent means. Hence, the trend of the successive backcrosses from the F_1 to the recurrent parent could be more readily established.

Most workers have used a different *S. tuberosum* parent in each successive generation of backcrossing. This is in accordance with the usual potato breeding procedure of crossing heterozygous clones to secure improved varieties. In following this procedure, the overall vigor of the backcross progenies tends to be greater than comparable progenies backcrossed continuously to the same parent. However, a backcross clone, to be of value as a parent, should have a minimum quantity of unfavorable genes from the non-recurrent parent along with a transmittable combination of favorable genes from the recurrent parent. Thus, it would seem that there is little or no advantage in using more than one parent until the effects of the undesirable genes from the non-recurrent parent are negligible. The loss in vigor resulting from the continued use of the same parent in successive backcross generations should not constitute a serious difficulty since, on the average, the vigor of the backcross progenies would approach but not be less than that of the self progeny of the recurrent parent. Moreover, the use of a single, rather than several parent clones, as a recurrent parent should increase the probability for selecting backcross clones more homozygous for the favorable genes from the recurrent parent.

For the most part, *S. demissum* has served as a source of qualitative genes conferring immunity to specific races of late blight rather than quantitatively conditioned characters, e.g., field resistance to late blight

or frost resistance. The rapidity with which genes of the non-recurrent parent were lost in this study, suggests that intensive selection is necessary in the BC_1 for retaining complexity inherited characters. The wide range in variation of BC_1 plants should provide ample opportunities for selection.

Summary

Two series of F_1, BC_1, BC_2 and BC_3 progenies of *S. demissum* x *S. tuberosum* were grown together with the self progenies of the parents. An S_3 *S. tuberosum* clone, 15-2-10-1-2, was used as the recurrent parent in one series, and an S_0 *S. tuberosum* clone, X528-170, in the other. Nine foliage and 3 tuber characters were studied in the seed propagated progenies grown in the greenhouse, and 6 foliage and 2 tuber characters in the clonally propagated progenies grown in the field.

For the F_1 progeny of *S. demissum* x *S. tuberosum* using the S_3 generation parent, 15-2-10-1-2, the means of the F_1 foliage characters were generally higher than those of the self progenies of either parent. The means of the F_1 for tuber characters were similar to those of S. demissum. In successive backcrosses to 15-2-10-1-2, the mean values progressively changed from the F_1 toward those of the recurrent parent and closely approached them in the BC_3.

For the F_1 progeny of *S. demissum* x *S. tuberosum* using the S_0 generation parent, X528-170, the means of foliage and tuber characters were generally equal to or lower than those of the self progenies of either parent. Means of the BC_2 and BC_3 progenies were approximately equal to those of the recurrent parent, X528-170.

Higher mean values were obtained in the F_1 from crosses of *S. demissum* with the S_3 than with the S_0 parent for all characters studied except one foliage character. The distinct differences between the self progenies of the two *S. tuberosum* parents were present in their respective BC_3 progenies. The results obtained suggest the plant and tuber characters of *S. tuberosum* recurrent parents can be approximated, in the absence of selection, by the BC_3 generation.

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SOIL AND PLANT POTASSIUM STUDIES WITH POTATOES IN KERN DISTRICT, CALIFORNIA[1]

K. B. Tyler,[2] O. A. Lorenz,[2] and F. S. Fullmer[3]

It is generally well known that potatoes are heavy users of potash in comparison with most other crops. Nutrient removal studies with potatoes grown in the Kern area showed that a 400-sack* crop removed from the soil slightly more than 250 pounds of potash (K_2O) per acre, of which about 200 pounds was by the tubers alone (2). Therefore it is not surprising that in some areas of California where potatoes have been grown almost continuously for a number of years a response to potash fertilization has been observed in potatoes, but not in other crops. Lorenz *et al.* (3, 4) have observed yield responses to potash fertilization of potatoes grown in Ripperdan and Hanford soils of Madera County, in Yolo and Pleasanton soils of the Santa Maria Valley, and in the organic soils of the San Joaquin Delta.

Only limited investigations have been made to study the requirements of potatoes in Kern County soils for additional potash. Fullmer (1), employing plant tissue analyses, rated a number of potato fields in Kern County low to deficient in potassium at midseason. He considered soils containing less than 75 parts per million of exchangeable potassium to be deficient and obtained high positive correlation between the potassium content of the soil and the amount in the petiole tissue. In these studies yield data were not obtained, therefore it was not known the degree to which the crop would respond to potash applications.

During the spring of 1957 many fields of White Rose potatoes in the Kern District exhibited unusual symptoms such as leaf rolling, mottling, and scorching followed by early discoloration and death of the foliage. Some of these abnormal conditions were associated with low potassium levels in the soil and in the plant, as determined by analysis of soil and of petiole tissue. The study described here was initiated to gain some insight on how potash fertilization might eliminate or alleviate these abnormal conditions in the potato fields. Soil analyses were used in combination with plant tissue tests and yield response to fertilization as criteria for evaluating the need for potash fertilization. An attempt was made to relate each of the three criteria to the other two. Potatoes of the White Rose variety were used exclusively in these studies.

In their original state, the soils used in these studies are alkaline-calcareous and have a pH ranging from about 7.0 to 8.0. Continuous cropping has increased the soil acidity and some of the soils are now as acid as pH 5.0. All of the soils are light-textured and are usually classified as fine sandy loams. Most of them are classified as belonging to Hanford, Delano, and Hesperia series. The organic matter content of the soils is very low — less than one per cent.

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*100 pounds per sack.

Materials and Methods

Eight growers' fields, one in southern Tulare County and seven in Kern County, were selected during the season of 1957-58 for replicated fertilizer experiments. Potash levels of 0, 100, 200, 400, and 1,000 pounds of K_2O per acre were used with standardized rates of 180 pounds of N and 120 pounds of P_2O_5 per acre. In two soils where the pH was about 4.7 an additional treatment involving the application of one ton of hydrated lime per acre was included. Each plot consisted of 4 rows 60 feet long. There were 4 plots of each fertilizer treatment in each experiment.

Prior to planting and fertilizing, soil samples of the surface ten inches were taken from the site of each field experiment and analyzed in the laboratory for exchangeable sodium, calcium, potassium, and magnesium. Analyses for the first three elements were made with a Perkin-Elmer Flame Photometer on a neutral, normal ammonium acetate extract of the soil. Magnesium in the extract was determined by the Thiazôle Yellow method. Sodium bicarbonate-soluble phosphorus in the soil was determined and soil pH measured with a glass electrode on a 1:1 soil-water suspension. Samples from uncropped areas adjacent to each field experiment were taken and exchangeable potassium determined in order to afford a comparison of potassium in cropped and uncropped soil.

The potato crop was planted with the fertilizer being placed simultaneously in bands about two inches to each side and two inches below the potato seedpiece, except for the 1,000 pound rate of potash in which case 400 pounds were banded and the remainder applied broadcast. Plant spacing in the row was 10 inches with 32 inches between rows. The growers prepared the seedbed, cultivated, irrigated, and harvested the potato crops in accordance with their own schedules.

During the growing season petiole samples of recently matured leaves were collected at approximately 2-week intervals and analyzed for potassium, calcium, and magnesium in the ashed samples. Petioles from the fourth fully expanded leaf from the tip of the plant were selected for analysis. Nitrate nitrogen and phosphate phosphorus soluble in 2 per cent acetic acid solution were also determined on the dried, ground samples. Yield and grade of tubers were determined at the time the potatoes were harvested.

In addition to the eight tests described above, which hereafter are referred to as the field experiments, twenty other growers' fields in Kern County were selected at random for the purpose of making a survey of the nutrient status of the three major nutrients in potatoes grown in the southern San Joaquin Valley. Soil samples were taken in these fields and analyzed as previously described. At four separate locations in each field duplicate plots two rows wide were fertilized with either 200 pounds P_2O_5 as treble superphosphate or 200 pounds K_2O per acre as sulfate of potash. These materials were applied in addition to fertilizer applied by the individual growers. Application was made by sidedressing the materials in bands about 4 inches to each side and about 2 inches below the seedpiece sometime after planting but prior to emergence. Leaf

petioles were collected and analyzed as was done for the eight field experiments.

Results and Discussion

The abnormal foliage symptoms as described earlier were eliminated or considerably reduced in the eight field experiments where the higher rates of potash were applied. Leaf rolling, scorch, and mottling were especially severe in most of these fields where potash applications were omitted.

Yields

The season of 1958 was generally unfavorable for potato production and yields were only about two-thirds of normal. It is believed that even greater effects would have been obtained from applied fertilizers under favorable weather conditions. Yield data from the eight field experiments (Table 1) indicate that at least 100 pounds of potash per acre were required in order to obtain maximum yield of tubers. In half of the field experiments a significant increase in yield resulted from the application of 100 pounds of K_2O per acre. The trend was identical in the remaining four, although differences were not large enough to be statistically significant. The average yield from the eight fields was 26 hundred pounds greater per acre where 100 pounds of K_2O per acre was used as compared with the 0 rate. Applications of 200, 400 and 1,000 pounds of potash per acre produced yields very similar to those obtained with the 100 pound applications. As might be expected, the largest yield increases resulting from potash application occurred in those fields where exchangeable soil potassium was lowest — 46 parts per million in one field and 70 parts per million in the other. Liming of fields 2 and 4 which had extremely acid soils (approximately pH 4.7) resulted in increased tuber yields.

TABLE 1.—*Fertilizer treatments and total yields of potatoes from eight fertilizer experiments.*

Fertilizer Treatment (Pounds per Acre)				Total Yields—Cwt. per Acre								Average 8 Fields
				Fields								
	N	P_2O_5	K_2O	1	2	3	4	5	6	7	8	
Soil Exch. K, ppm →				(101)	(106)	(104)	(105)	(70)	(46)	(101)	(93)	
1.	180	120	0	211	156	195	194	174	194	296	386	226
2.	180	120	100	212	161	229	218	230	258	341	408	257
3.	180	120	200	230	175	217	206	224	266	304	391	252
4.	180	120	400	214	176	193	222	221	254	313	406	250
5.	180	120	1000	..	171	211	232	210	298	310	379	
6.	180	120	200*	..	207	..	226	..	..	..	..	
L.S.D. 5 per cent				44	34	14	30	42	42	43	48	

*One ton hydrated lime broadcast prior to planting.

Plant analyses

The various samplings of potato plants were classified into three categories according to the age of the plant: Early — about 70 days from planting at which time plant foliage began to cover the furrows and the plants were in full bloom; Midseason — about 85 days — tubers were about two-thirds their mature size; and Late — about 100 days or later at which time foliage was mature and yellowing. Using this classification for time of sampling, the data permit the establishment of the three levels or ranges for potassium in the leaf petioles as given in table 2.

Plant potassium analyses made on midseason samples from the eight field experiments are summarized in table 3. According to the criteria given in table 2 for leaf potassium, five of the eight fields were deficient in potassium at midseason and the remaining three in the lower portion of the medium range. In every case the application of 100 pounds of

TABLE 2.—*Classification of potassium levels in the leaf petiole of White Rose potato plants.*

	Approximate No. of Days from Planting	Level of Potassium in Petiole Tissue[1]		
		Deficient	Medium	Sufficient
		Per cent K[2]	Per cent K[2]	Per cent K[2]
Early	70	Less than 9[3]	9 - 11	More than 11
Midseason	85	Less than 7	7 - 9	More than 9
Late	100	Less than 4	4 - 6	More than 6

[1]Petiole of 4th mature leaf from growing tip.
[2]Dry weight basis.
[3]Foliar symptoms of potassium deficiency usually are not present at this stage of plant growth but will appear as plants mature.

TABLE 3.—*Per cent potassium* (K) *in potato petioles at midseason.*

Potash Applied Lbs. per Acre[1]	Per cent Potassium (K) in Leaf Petiole							
	Experimental Fields							
	1	2	3	4	5	6	7	8
Exchangeable Soil K→ ppm	(101)	(106)	(104)	(105)	(70)	(46)	(101)	(93)
0	7.8	6.6	7.4	7.9	1.7*	3.4*	6.4*	5.6*
100	9.4	8.6	7.7	8.3	6.2*	6.0*	8.5	8.4
200	10.6	8.3	9.2	7.6	8.2	8.0	9.8	9.8
400	10.8	10.5	10.3	9.0	9.2	11.6	10.4	10.8
1000	..	13.4	11.2	9.8	11.4	10.4	11.7	12.8
200[2]	..	10.6	..	7.2	..	..	..	..

[1]All treatments included 180 lbs. of N and 120 lbs. of P_2O_5 per acre.
[2]Plus one ton of hydrated lime applied broadcast.
*Considered to be potassuim deficient (less than 7 per cent) at midseason.

potash per acre resulted in an increase in the potassium content of the leaf. In fields 5 and 6 where the soil was very low in exchangeable potassium, plants were still within the potassium-deficient range even after 100 pounds of potash had been applied. At the last sampling (Table 4), three of the five fields which were classed as being deficient at midseason were again found to be in the deficiency range. Three other fields were definitely on the borderline. Consistent increases of plant potassium occurred with increasing rates of potash applied to the soil in all fields. Extreme ranges of potassium content in the plants are shown by these data. Potassium values were found as low as 0.6 per cent and as high as 14 per cent. Certainly it is evident from these data that high potassium levels can be maintained in plants growing on potash-deficient soils if 400 pounds or more of potash are applied. The application of 200 pounds of potash per acre raised the potassium content of all plants above the proposed deficiency level, however. In all fields except one, the 1,000-pound rate of potash application resulted in higher plant potassium levels than did the 400-pound rate. However, in every field the 400-pound rate produced plants containing more than six per cent potassium at the last sampling. This would place these plants in the class suggested as having ample potassium.

Soil analyses

Results of soil analyses for the eight experimental fields are presented in table 5. Exchangeable soil potassium was found as low as 46 parts per million and as high as 106 parts per million. All of these potassium values would be considered low to deficient for potatoes by most standards. Potassium values in uncropped soils adjacent to the experimental plots were much higher generally than their counterparts in the field. These differences indicate the extent to which these soils have been depleted of potassium through cropping.

Soil pH of the eight fields ranged from acid to slightly alkaline. The low pH of the acid soils has resulted from applications of sulfur to the soil to prevent potato scab and from continuous use of residually acid nitrogen fertilizers such as ammonium sulfate. The extent to which the pH has been lowered in these soils can be estimated by comparing the pH of cropped soils with that of uncropped soils.

In two of the eight fields where exchangeable soil potassium was lowest, the greatest yield responses from potash application were observed. In experimental field 6 the soil potassium level was 46 parts per million. Plant potassium was in the deficiency range in both the midseason samples and in the final samples from this field where no potash had been applied. Yield was increased by 33 per cent with the application of only 100 pounds of potash per acre and 200 pounds increased the yield 38 per cent over the no potash treatment. Likewise, in field 5, where soil potassium was 70 parts per million and plant potassium was in the deficiency range where no potash was applied, the increase in yield resulting from 100 pounds of potash was 31 per cent. Trends in most other fields were similar in nature although the differences and increases were smaller in proportion.

Potassium analyses of the soils and plants of the 20 fields in Kern

TABLE 4.—*Per cent potassium (K) in potato petioles at last sampling.*

Potash Applied Lbs. per Acre[1]	Per cent Potassium (K) in Leaf Petioles							
	Experimental Fields							
	1[3]	2	3[3]	4	5	6	7	8
Exchangeable Soil K→ ppm	(101)	(106)	(104)	(105)	(70)	(46)	(101)	(93)
0	7.8	4.8	7.4	4.5	0.6*	1.1*	4.2	2.4*
100	9.4	7.1	7.7	6.1	3.0*	4.7	7.1	4.4
200	10.6	8.7	9.2	6.4	5.8	5.4	7.6	5.2
400	10.8	10.4	10.3	8.6	8.6	9.7	10.7	7.5
1000	..	14.0	11.2	8.6	9.7	11.2	11.7	9.1
200[2]	..	10.2	..	6.9	..	..	..	..

[1]All treatments included 180 pounds of nitrogen and 120 pounds of P_2O_5 per acre.
[2]Plus one ton of hydrated lime applied broadcast.
[3]Last sampling taken when plants were physiologically at midseason growth stage.
*Considered to be in the range of potassium deficiency (less than 4 per cent at late season).

TABLE 5.—*Analyses of soil samples from eight potato experimental fields. Kern and Tulare Counties, 1958.*

Field No.		Soil pH	Exchangeable Cations, ppm[1]				PO_4-P[2] ppm
			K	Mg	Ca	Na	
1	Cropped	6.0	101	248	1062	69	142
	Uncropped	7.8	193	183	2282	90	56
2	Cropped	4.6	106	127	1008	250	159
	Uncropped	6.7	275	142	950	96	41
3	Cropped	4.6	104	55	688	59	80
	Uncropped	6.6	180	92	1125	18	41
4	Cropped	4.7	105	61	578	67	151
	Uncropped	6.9	287	101	1052	95	47
5	Cropped	6.9	70	77	878	40	101
	Uncropped	6.7	201	124	1002	50	46
6	Cropped	7.0	46	70	562	43	80
	Uncropped	8.0	132	84	888	86	57
7	Cropped	7.1	101	88	950	69	111
	Uncropped	7.8	435	114	989	30	40
8	Cropped	7.4	93	110	693	83	41
	Uncropped	6.0	149	160	889	46	44

[1]Average of several soil samples.
[2]Sodium bicarbonate extractable phosphorus expressed on dry soil weight basis; average of several soil samples.

TABLE 6.—*Soil and plant potassium from 20 potato nutrient survey fields in Kern County, California. 1958.*

Exchangeable Soil K, ppm.	Per cent Potassium (K) in Petiole[1]	
	No K Applied	200 Lbs. K_2O Applied
100	5.8	8.4
103	2.8	6.4
108	7.8	8.3
112[3]	3.7	5.2
119	7.1	11.7
128	6.4	7.2
131	7.6	8.8
133	7.9	9.5
145	6.6	9.7
147	5.9	9.0
160	7.0	8.0
164	10.0	11.4
165	6.5	9.8
171	8.0	9.5
174	7.3	10.2
192	5.9	8.9
204	9.6	10.4
207	7.8	8.8
334[4]	10.9	10.8
363[4]	8.6	8.5

[1]At last sampling of season, average of 4 samples.
[2]Applied after planting in addition to growers' application of nitrogen and phosphorus.
[1]At last sampling of season, average of 4 samples.
[4]These fields received approximately 10 tons of manure prior to planting.

County used for a survey of plant nutrients in potatoes are presented in table 6.

Exchangeable soil potassium in the 20 fields ranged from 100 parts per million to 363 parts per million. Soils low in potassium generally were those having a longer history of cultivation and of potato production. In two soils having very high exchangeable potassium values — 334 parts per million and 363 parts per million — the land had been under cultivation only a few years and also had been heavily fertilized with steer manure during these years. In some cases cropped land was only slightly lower in potassium than uncropped land.

Plant tissue analyses of the potato petioles showed that potassium content of the plants grown without applied potash ranged from abundant to deficient, with most values falling in the range of sufficiency. Except for the two fields mentioned above, which had very high soil potassium, application of 200 pounds of potash per acre resulted in increased potassium content of the plant even though the soils contained sufficient potassium so that yield increases would not be likely.

Potassium values in the plant petioles are plotted against potassium in the soil in figure 1. As soil potassium falls below 100 parts per million,

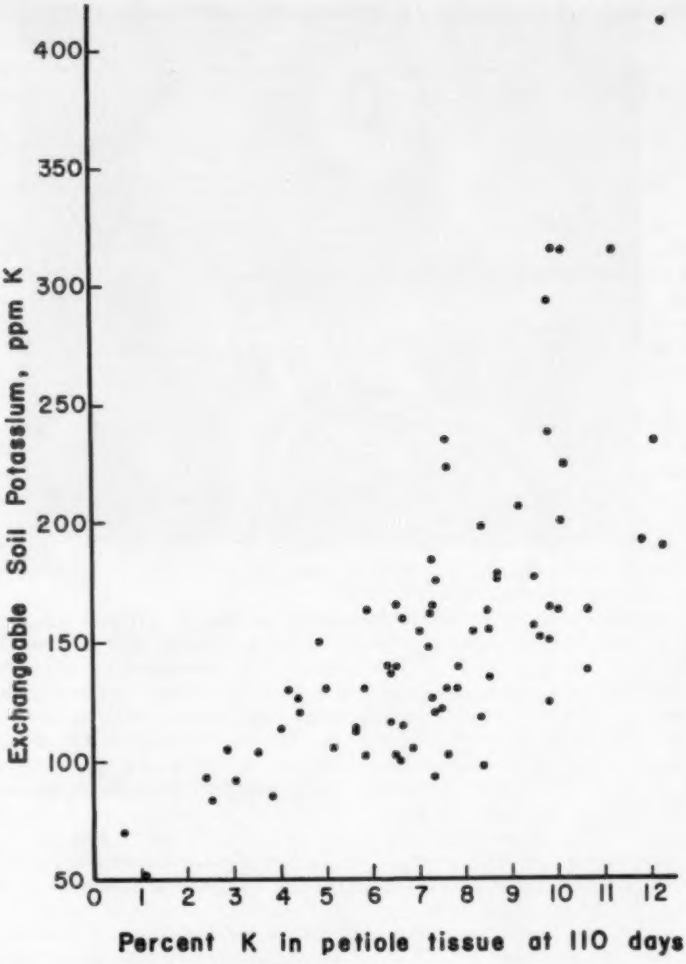

FIGURE 1.—Relationship between per cent potassium in potato leaf petioles and exchangeable potassium in the soil.

plant potassium is generally in the deficient range — less than 4 per cent at late season. The points between 100 and 150 parts per million are scattered, indicating yield response to potash application may or may not be likely. Above 150 parts per million soil potassium all the points on the graph except one are in the high range, thus indicating a response to potash unlikely. With this information available the critical levels of

exchangeable potassium in these light-textured soils with respect to potatoes are suggested as follows:

Less than 100 ppm — Deficient — Responds to potash fertilization
100 to 150 ppm — Low — May or may not respond to potash fertilization
150 to 200 ppm — Medium — Unlikely to respond to potash fertilization
More than 200 ppm — Sufficient — No response to potash fertilization

This classification of soil potassium should be used only as a general guide. With potatoes, as in many other crops, soil tests are most effective and reliable for predicting potash need when used in combination with other criteria such as plant tissue tests and yield results. In situations where it is impossible to have available this other information for determining need, one should not hesitate to go by the results of soil tests alone.

Summary

Symptoms of potassium deficiency exhibited by leaf mottling, scorch, and rolling, especially of the younger leaves, were corrected by potash fertilization. Yields were likewise increased by the use of potash. On the more deficient soils it was necessary to add at least 200 pounds of K_2O per acre to eliminate deficiency symptoms of the foliage. It was necessary to apply more than 100 pounds of potash per acre to obtain maximum yields but yield increases were not obtained by applying more than 200 pounds of potash per acre.

Potassium levels in the petiole tissue as low as 0.6 per cent and as high as 14 per cent were obtained. Potassium levels of less than 9 per cent during early growth, 7 per cent at midseason, and 4 per cent at late season were associated with potassium deficiency symptoms in the foliage and reduced yields. On some soils satisfactory levels of potassium in the plant were obtained by applying 100 pounds of K_2O per acre, but in the most deficient soils it was necessary to apply 200 pounds. In all soils, high levels of plant potassium were obtained from K_2O application of 400 pounds or more per acre.

Soil levels of exchangeable potassium of 100 parts per million or less were associated with reduced yields, low plant potassium content, and deficiency symptoms in the plant. Levels of 150 parts per million or more were sufficient for these soils.

There was excellent agreement between the potassium content of the soil, and the response of the crop to potash application as determined both by yield and potassium content of the petiole tissue.

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DR. DONALD JOHN MACLEOD HONORED

It is my privilege tonight to present Dr. D. J. MacLeod as a candidate for Honorary Life Membership in the Potato Association of America.

When I was asked to perform this very pleasant task I thought that I would look into the history of the MacLeod Clan. I found that whenever an award of merit had been made to a MacLeod it was invariably accompanied by the music, sound, wail, or whine of the bagpipes. You have heard that delightful music tonight.[1] Yet when someone, not connected with the organizing committee, suggested that pipe music be played, it was before any of us had knowledge that Dr. MacLeod was to be honored. The piper even wore one of the MacLeod tartans. Apparently the little people or leprechauns of the Western Isles of Scotland still look after their own no matter where they wander.

Academic Career — Donald John MacLeod was born on a farm in 1894 some 60 miles east of Ottawa at Dunvegan, Ontario, where he spoke in Gaelic and in French before he knew that there was an English language. He graduated from Queen's University, Kingston, Ontario, with a B.A. in medical bacteriology in 1921 and obtained his M.A. in 1923. Between 1921 and 1923 he was awarded three National Research Council Fellowships.

In 1937 D. J. MacLeod felt a need for more advanced knowledge in the narrow specialized field of potato viruses. He went to Cambridge, England, and studied under Dr. Redcliffe N. Salaman and Dr. Kenneth M. Smith at that time both outstanding in their respective fields of work, potato breeding and potato viruses. He obtained the Ph.D. from

[1]Guests were piped into the banquet room by a bagpiper.

Cambridge on presentation of his thesis, "Mosaic Diseases Attacking Potatoes in Canada." When I examined this thesis in the Cambridge University Library at the suggestion of a Brazilian colleague, I found it to be of 3 volumes of which 2 were wholly of excellent photographs — some 630 in all, and each painstakingly mounted. The word painstaking describes Dr. MacLeod's approach to all of the problems that he investigated during his professional career.

Professional Career — In 1924 D. J. MacLeod came to Fredericton to take charge of the Laboratory of Plant Pathology for the Department of Agriculture in the Dominion Government, and he remained as Officer-in-Charge until March 31 of this year. Dr. MacLeod retired officially on June 30, 1959 but he has been retained by the Canada Department of Agriculture until the end of August to write a bulletin on potato virus diseases. Consequently it is most appropriate that the honor you wish to bestow upon him be made at this time.

From 1924 until about 1932 D. J. MacLeod tested potato seedlings for resistance to late blight and other potato diseases for both Dr. D. Reddick of New York State, and Dr. C. F. Clark of Maine and of the U.S.D.A. These seedlings included the eventual Katahdin and Chippewa varieties. He also cooperated extensively with Dr. D. Folsom of Maine.

In 1933 a potato breeding project was inaugurated at Fredericton consequent upon a report, and its recommendations, jointly made by D. J. MacLeod and L. C. Young. This report was based on information and materials obtained during visits to the prominent research workers and centers of potato breeding and related work in the U.S.A. Dr. F. A. Krantz of Minnesota and Dr. J. Johnson of Wisconsin were amongst those visited. That project has developed into Canada's National Potato Breeding Project of today,and before his retirement Dr. MacLeod has seen some of the fruits of this project in the release of the five varieties — Keswick, Canso, Huron, Avon and Fundy.

The work that was developed under Dr. MacLeod at the Fredericton Laboratory over the years eventually covered investigations into most of the potato diseases of economic importance. Until recent years potato seed certification in this province also came under his direction. His contributions to literature have included bulletins on black-leg and potato scab, and articles on potato viruses, particularly purple-top. He is a Past President of the Canadian Phytopathological Society.

In his quest for advanced knowledge, and to give kindly advice to others seeking help, Dr. MacLeod has travelled extensively in Europe, U.S.A. and Canada. In 1956 he headed a 3-man mission to Venezuela to advise the Government of that country on potato problems. He also visited neighboring countries and made a pilgrimage to the supposed home of the potato — Lake Titicaca.

In 1957 he was invited by the Government of Bermuda to investigate the virus diseases of lilies on these islands.

D. J. MacLeod married Hazel Parks in 1927. They have one child, a daughter, who is a graduate with the masters degree in nursing from Yale University. Mrs. MacLeod is a painter, and an artist of some local repute.

Dr. MacLeod likes all things Scottish and consequently this attraction

to the potato is innate. I am sure that he believes that to call the potato the Irish potato is quite wrong because although the Irish either like or had to like the potato, the Scot is its epicure. The Scots have contributed as much in recent years to the improvement of the potato as any other single country. In the Old World "Scotch seed" and the "best possible potato seed" are synonymous terms.

It is therefore with great pleasure that I present to you Dr. Donald John MacLeod for your recognition.

—*James Munro*

NORMAN MacLEOD PARKS HONORED

Born in Orangeville, Ontario. He first worked for the Federal Department of Agriculture in 1936 as a student assistant and in 1939 became Agricultural Assistant, then Senior Agricultural Assistant, later Agricultural Scientist and finally Agricultural Research Officer. Norman holds a B.S.A. degree from the University of Toronto and has completed all his class work for M.S.A. degree from the same institution.

He worked on potato improvement during the above mentioned dates. First his efforts were confined to the Province of Ontario where he did excellent work and gained the respect and praises of the growers, dealers and provincial officials as well as those of his own Department.

In 1946 he was transferred to Ottawa from Guelph and his scope of duties was widened to take in all of Canada. He is well known to potato people from coast to coast in Canada. He has travelled extensively in the United States and in 1958 attended and addressed the International Horticultural Congress in Nice, France. He had several invitations to visit other European countries but due to illness had to return to Canada.

As many of you know he has worked untiringly for the benefit of the Potato Association for many years and held many offices and in 1958 was President.

I have been closely associated with Norm for many years and have always found him to be very cooperative.

Norm is married and has three lovely children in addition to a marvelous wife, I might add that the children are all good looking and do not resemble their father too much. For a winter pastime he curls and from what I have been told is really good at the game.

I am pleased to present Norman MacLeod Parks for an Honorary Life Membership in our organization.

—*J. W. Scannell*

DR. GEORGE COCKERHAM HONORED

It is indeed a very great privilege for me to be sponsoring my very good friend, Dr. George Cockerham, as an honorary life member of the Potato Association of America.

George Cockerham was born in Clayton, Yorkshire, England, on November 18, 1908. After high school he attended the University of Leeds, and graduated with honors in 1929.

His graduate studies were at the University of Edinburgh where he

was awarded the degree of Doctor of Philosophy in 1937. His thesis was "Genetical and Physiological Studies of the Potato (*Solanum tuberosum*)". A portion of his thesis "Heritable possibilities of resistance to virus diseases" is a subject that George still has his hands on today.

After his graduate work, in 1937 George joined the staff of the Scottish Plant Breeding Station where he had been affiliated since leaving the University of Leeds in 1929.

Dr. Cockerham's studies have been in the field of breeding for resistance to virus diseases in the potato. His early work comprised (1) The resolution of virus disease complex, (2) testing existing varieties for resistance to potato viruses, and (3) interbreeding virus resistant varieties.

More recently George has studied the mode of inheritance of various forms of resistance to virus in commercial varieties and wild potato species, and has synthesized from these, material suitable for breeding new potato varieties.

It was during my visit to his laboratory in 1946 that I personally became acquainted with George and with his outstanding work. Many of you became acquainted with George during his brief visit to Canada and also during his 6-month stay at the University of Wisconsin as a post doctorate fellow in 1952.

It is with a great deal of pleasure that I present to you, *in absentia*, Dr. George Cockerham, and congratulate him on his election to Honorary Life Membership in The Potato Association of America — an honor he so richly deserves.

—R. H. LARSON

MINUTES OF ANNUAL BUSINESS MEETING OF THE POTATO ASSOCIATION OF AMERICA

University of New Brunswick, Fredericton, Canada
August 13, 1959

9:30 A.M. — Meeting called to order by President W. J. Hooker.

Program Committee report, by R. V. Akeley. Thirty-three papers concerning all phases of potato investigations were presented. Also, eight invitational papers on potato viruses were presented by six representatives from six foreign countries.

Membership Committee report, by O. C. Turnquist. Accepted.

Editorial Board and Handbook Committee reports were presented by J. C. Campbell and accepted.

Honorary Life Membership Committee report was presented by N. M. Parks and accepted. New members elected were D. J. MacLeod (Canada), N. M. Parks (Canada) and George Cockerham (Scotland).

Policy Committee report was presented by P. J. Eastman and accepted.

Late Blight Investigations Committee report was presented by W. R. Mills for C. J. Eide and accepted. It was suggested that one of the committee members write an annual report for publication.

Potato Utilization Committee report by R. H. Treadway was read and accepted.

Potato Nutrition Committee report by G. V. C. Houghland was presented and accepted.

The Committee Report on Local Arrangements was given by L. C. Young and accepted.

The Varietal and Nomenclature Committee report was presented by O. C. Turnquist and accepted.

The Committee Report on Genetics and Cytology of Tuber Bearing Solanums was given by L. A. Dionne and accepted.

The Reports of Committee on International Relations and Invitational Papers for 1959 were presented by R. H. Larson and accepted.

Coordination of Committees was reported by P. J. Eastman and accepted. Fine cooperation and response was obtained from most committee chairmen.

R. V. AKELEY, *Secretary*

MINUTES OF EXECUTIVE COMMITTEE MEETING

New Brunswick University
Thursday, August 13, 1959

9:30 P.M. — Meeting called to order by W. J. Hooker.

Members present: W. J. Hooker, J. C. Campbell, O. C. Turnquist, R. V. Akeley, N. M. Parks, E. J. Wheeler, C. E. Cunningham, D. S. MacLachlan, and P. J. Eastman.

Discussion of financial status and membership fees. The price is to remain unchanged since the financial situation of the Association is better than last year.

Discussion of Potato Handbook. Decided to print 5,000 copies of the 1960 issue on Potato Utilization. A *motion* by P. J. Eastman and seconded by J. C. Campbell that we publish the Potato Handbook in 1961 was carried. After some discussion President Hooker appointed a committee of four, Eastman, Akeley, Turnquist and Campbell to discuss an appropriate title for the 1961 issue.

Discussion of payment of membership fees to AIBS. A *motion* by D. S. MacLachlan and seconded by O. C. Turnquist that the Potato Association of America discontinue its affiliation with the American Institute of Biological Sciences was carried.

Discussion of use of seal and crest by the Potato Association. President Hooker appointed N. M. Parks and D. S. MacLachlan, a committee of two, to design a seal and crest for use by the Association.

A *motion* by O. C. Turnquist and a second by C. E. Cunningham that the Potato Association of America accept the varietal description format presented by the Varietal Description Committee as a standard to follow in future releases was carried.

The Executive Committee accepted the invitation of the American Phytopathological Society to meet with them at Greenlake, Wisconsin, August 28-31, 1960. The time and place for the 1961 meeting will be discussed before the general business meeting.

A *motion* by P. J. Eastman that the editor of the Potato Handbook should continue as editor in the future and also should receive 15 per cent of all advertising fees was seconded by W. J. Hooker, and carried

A *motion* by N. M. Parks that future nominations of honorary life membership shall not be carried over from year to year was seconded by P. J. Eastman and carried.

R. V. AKELEY, *Secretary*

MINUTES OF ANNUAL BUSINESS MEETING THE POTATO ASSOCIATION OF AMERICA

Saturday, August 15, 1959

A moment of silence was observed in memory of the following deceased friends and colleagues: Reiner Bonde, J. L. Howatt, F. A. Krantz, and John Tucker.

Treasurer's report by J. C. Campbell was approved. *Motion* by P. J. Eastman was seconded by G. V. C. Houghland and carried.

Auditing Committee report by G. V. C. Houghland; books were found in order. *Motion* by E. J .Wheeler, seconded by W. R. Mills and carried.

O. C. Turnquist, Chairman of the Membership Committee urged members to emphasize group membership in the future.

Report by President Hooker on the action of the Executive Committee not to join the American Institute of Biological Sciences because of the increase in dues to $200 and because we could not meet with them at least until 1961.

Varietal description outline discussed by O. C. Turnquist. A *motion* by O. C. Turnquist and seconded by N. M. Parks that this form for varietal descriptions be adopted by the Potato Association of America as official was carried.

A report of the temporary committee on a proper seal and crest for the Association was given by N. M. Parks and the committee was given authority to prepare samples for approval.

Announcement that next year's meeting will be held in conjunction with the American Phytopathological Society, August 28-31 was made by President Hooker. H. O. Werner invited the Potato Association to meet at Lincoln, Nebraska in 1961. P. J. Eastman suggested a special committee be appointed to study the relationship of the Potato Utilization Conference and the Potato Association of America.

Dry-matter content and conversion methods were discussed by members. It was decided that a committee be appointed to look into methods of standardization.

Resolutions Committee report was presented by C. E. Cunningham. The following resolutions were adopted. BE IT RESOLVED THAT:

1. Whereas the Potato Association of America at its 43rd Annual Meeting has had an excellent program of activities, we wish to express our appreciation to the various members of the Local Arrangement Committee for making such excellent arrangements, including the ladies activities.

2.. The Potato Association of America wishes to express its appreciation for the voluminous and favorable press, radio, and TV coverage of our 43rd meeting.

3. The 43rd Annual Meeting of the Potato Association of America has been a success largely due to the commodious accommodations and other facilities provided by the University of New Brunswick, and we wish to express our appreciation for their wholehearted cooperation.

4. The members at the 43rd Annual Meeting wish to extend their thanks to the Canada Department of Agriculture with special reference to Mr. Smith Hilton, Director of the Research Station for the sumptuous chicken barbecue provided to the delegates and their families on the station

grounds and for the conducted tours provided to those in attendance.

5. Members at the 43rd Annual Meeting of the Potato Association of America wish to express their thanks to the management and staff of the Lord Beaverbrook Hotel for the excellent arrangements provided for the Annual Recognition Banquet.

6. The tour of the Saint John Valley was greatly enhanced by the wonderful luncheon provided by the McCain Produce Company and McCain Foods Limited of East Florenceville, and the members of the Potato Association of America wish to express their appreciation to this Company and all their associates in supplying this fine meal and the conducted tour of their plant.

7. Members of the Association on tour were provided with an excellent meal at Grand Falls, N. B., through the generosity of the Valley Cooperative and Mr. Ridout, and wish to thank them for their thoughtfulness.

8. Members of the Potato Association were agreeably surprised to be provided with courtesy parking cards and wish to thank the City Fathers and their Police Department for this courtesy to the delegates from outside the Province of New Brunswick.

9. Members of the Potato Association of America, at their 43rd meeting, have been honored by the attendance of delegates from Germany, Denmark, the Netherlands, Poland, Sweden, and Brazil, who joined with us in our deliberations and added new viewpoints for our enlightenment. Therefore, the Association wishes to thank these world-renowned individuals for their participation and Dr. R. H. Larson, Chairman of the Foreign Relations Committee, for his untiring efforts in arranging for the invitational papers which they presented.

10. The members of the Potato Association wish to express their thanks and appreciation to the Provincial Government of New Brunswick for its generosity in supplying a lobster barbecue during the tour of the Alma Potato Breeding Station.

Report of the Nominating Committee was presented by E. J. Wheeler as follows: P. J. Eastman, President; O. C. Turnquist, President-elect; R. V. Akeley, Vice-President; and W. C. Sparks, Direcotr. J. C. Campbell moved that nominations be closed and that a unanimous ballot be cast for the slate. Seconded by N. M. Parks. Motion carried.

R. V. Akeley, *Secretary*

MINUTES OF EXECUTIVE COMMITTEE MEETING

New Brunswick University

Saturday, August 15, 1959

11:00 A.M. — Meeting called to order by President Eastman.

Members present: E. J. Wheeler, R. V. Akeley, W. J. Hooker, O. C. Turnquist, P. J. Eastman, C. E. Cunningham, and J. C. Campbell.

R. L. Sawyer was elected secretary of the Association for 1960-1961

The motion made by O. C. Turnquist and seconded by E. J. Wheeler for the Potato Association to purchase 100 binders for sale to members was passed.

The motion made by C. E. Cunningham and seconded by O. C. Turnquist that we elect two technical and one non-technical men for honorary membership in 1960 was carried.

R. V. Akeley, *Secretary*

FINANCIAL REPORT
THE POTATO ASSOCIATION OF AMERICA
August 1, 1958 to July 31, 1959

RECEIPTS		
Balance in checking account, July 31, 1958	$4,220.30	
Annual dues	6,844.06	
Sale of advertising in Journal	3,011.77	
Sale of reprints	2,664.15	
Sale of back issues	215.57	
General, meeting, books, etc.	213.30	
Sale of Handbooks	779.50	
Advertising in '58 Handbook	250.00	
Advertising in '59 Handbook	1,660.00	
Advertising in '60 Handbook	125.00	
TOTAL RECEIPTS		$19,983.65
DISBURSEMENTS		
Printing Journal (12 issues)	6,735.44	
Mailing & Supplies	953.94	
Printing reprints	1,232.45	
Purchase of back issues	51.20	
Salaries, E. Campbell (Bookkeeping, Billing, etc.)	720.00	
J. Campbell (Editing Journal)	900.00	
E. Clark (Proof reading Journal)	330.00	
Commission on Journal Advertising	409.11	
General, meeting, books, bank charges, etc.	301.02	
Commission on '58 Handbook (Hutchinson)	62.50	
Commission on '59 Handbook (Hutchinson)	166.00	
Salary editing '59 Handbook (Hutchinson)	416.67	
Printing & mailing '59 Handbook	1,786.15	
Salary of editing '60 Handbook (Campbell)	500.00	
Miscellaneous Handbook expenses	84.23	
TOTAL DISBURSEMENTS		$14,655.18
Balance in checking account, July 31, 1959		5,428.47

— SAVINGS ACCOUNTS —

Family Savings & Loan Association		
In bank July 31, 1958	$2,025.00	
Interest	61.19	
TOTAL		$ 2,086.19
Lelah Starks Fund		
In savings account July 31, 1958	$ 538.52	
Interest	12.19	
TOTAL		$ 550.71
Disbursements from Starks Fund		
Reprints for E. Kissmeyer Nielson	12.50	
Reprints of International Potato Research Projects	68.20	
Total		80.70
BALANCE in Starks Fund		470.01
TOTAL ASSETS, July 31, 1959		$ 7,884.67

REPORT OF POTATO NUTRITION (FERTILIZATION) COMMITTEE

Many scientists concerned with the nutrition of the potato crop are becoming increasingly aware of the changes taking place in this field of study, as in other biological fields. New methods, new concepts, new approaches to old problems all are in keeping with the times and are naturally considered signs of progress. However, it is not always so clearly recognized that the equally important task of evaluating these changes in terms of current usefulness and of economic returns is also the responsibility of the nutrition specialist. In short, although change is inevitable it is of little value unless it is for the better.

Mindful of all this, your committee on potato nutrition has chosen to concern itself, for the purpose of this report, with certain newer developments and to attempt to clarify thinking, wherever possible, in regard to the usefulness of these developments in potato production.

Soil and Plant Tissue Testing

Much of the early work on plant nutrition undertook to pinpoint the exact combination of nutrients thought to be required for optimum yields of specific crops. The results of this research, often employing solution culture techniques in the greenhouse, when transplanted into field recommendations tended to create abnormal demands for hundreds of fertilizers of different analyses. Today, however, through the aid of soil and/or plant tissue tests, potato growers can confidently choose their fertilizer requirements from less than half a dozen mixtures. This sound procedure of selecting fertilizers according to the available nutrients in the soil and on a basis of the needs of the crop is rapidly growing in popularity.

In potato-growing sections like Long Island yearly information obtained from soil tests is being accumulated for a period of years to serve as a basis for long-range recommendations. In this way soil fertility levels are expected to be so manipulated as to avoid the occurrence of problem cases, except possibly in seasons with abnormal weather. However, where nutrient deficiencies do occur in soils showing no shortage by soil tests, leaf tissue are being used to help clear up these problem cases.

In California, soil analyses and plant tissue tests are being used to estimate fertilizer requirements for potatoes, especially on light-textured soils. Here the primary concern centers around phosphorus and potassium; nitrogen analyses have little meaning since all the soils require liberal nitrogen fertilizer. Low, medium, and high levels of soluble phosphorus and exchangeable potassium have been established and these serve as guides for fertilizer recommendations. Phosphorus, it is interesting to note, is determined by a bicarbonate method, whereas in the East some type of acetic acid extraction is usually used. Both methods are properly used in their respective locations and this points up the fact that there is no need for uniformity in soil tests. So long as the method used has been tested empirically and found to indicate yield responses, its relation to tests used elsewhere is merely incidental.

The same reasoning applies to plant tissue tests. In California, nitrogen

and phosphorus are determined on a 2-per cent acetic acid extraction of the dried petiole tissue from the fourth oldest leaf. But potassium absorption is assessed by analysis of the ashed petiole tissue Here again levels have been established for normal yields, but for the plant tissue tests these are minimum levels. For the interpretation of plant tissue tests it is essential to relate all analyses to the stage of plant growth when the samples were taken. The composition of the major nutrients in potato vines, with the possible exception of calcium, changes rapidly during the growing season because of translocation and utilization in metabolism. Low potassium or phosphorus in the leaf petioles after midseason, for example, could mean merely that these two nutrient elements had been readily utilized in the metabolism of starch for the tubers. As a consequence, tissue tests made before midseason are apt to prove most helpful since deficiencies indicated at that time are likely to have been caused by soil deficiencies. Moreover, at midseason there may still be time to correct the deficiency by supplying the nutrient needed. .

Despite the progress being made with soil and plant tissue tests there is, nevertheless, an urgent need for more work on methods designed to coordinate the results from both types of tests so they may both be used to best advantage.

In all our attempts to devise better methods for fertilizer recommendations we should always remember that the final evaluation of the test results and their translation into recommendations are the job of the nutrient specialist. In the past, several attempts have been made to circumvent this human element wholly or in part through the use of master fertilizer response curves, but these attempts have never been highly successful nor have they been well received by agronomists. The most recent version of the mathematical approach to soil fertility problems involves the use of an electronic calculator. But even with this modern innovation there is still an essential need for the judgment of the nutrition specialist in programming the data supplied the machine and in evaluating the results that come out.

Soil testing also has proved helpful to both State officials and fertilizer manufacturers when it has become necessary to adjust the analyses of fertilizers recommended for potatoes so as to be more in line with test-indicated nutrient requirements. For example, tests made on potato soils in Baldwin County, Alabama showed a low P - K nutrient ratio requirement in 25 per cent of the fields tested, but statistics showed that only 1 per cent of the fertilizer sold in the area had such a ratio. Again, the tests showed that only 1 per cent of the potato soils called for a high N - P nutrient ratio, while 37 per cent of the fertilizers sold in the area had such a ratio. Finally, the soil tests showed that 75 per cent of the soils needed a 1 to 1 P - K nutrient ratio, but tonnage records showed that 62 per cent of the fertilizer sold had this ratio.

It cannot be assumed, of course, that the proper fertilizer mixture will always be used on the field it was intended for, but there is little chance for this to happen unless the right fertilizers are made available. The bulk of the potato growers buy their fertilizer ready-mixed so it is obvious that full cooperation of the manufacturers will help to effect the indicated changes. Soil testing as a means of determining fertilizer require-

ments for potatoes is growing in importance in Alabama and elsewhere throughout the South as well as in California and other parts of the United States and in Canada.

Foliar Fertilizer Sprays

Increasing interest in soil and plant tissue testing is perhaps commensurate with decreasing interest in the use of fertilizer sprays. This shift of interest is undoubtedly a result of the full realization that plant roots and not leaves are the natural organs of nutrient absorption. While it has been shown that some leaf absorption takes place from nutrient sprays applied to potato vines, the amount normaly is exceedingly small compared with that absorbed through the roots. Moreover, the absorption period from the soil normally extends throughout the growing season whereas the period for leaf absorption from sprays is of short duration. This difference in absorption periods makes the time of application of foliar sprays a critical factor that is difficult to deal with. Apart from emergency use to supply small amounts of minor elements where the need is urgent, foliar nutrient sprays seem to offer little of value in the usual potato nutrient program. The use of nutrients dissolved in soil irrigation water, however, is an entirely different nutritional approach that merits further experimental study and development.

Twin-row Planting

The twin-row planting idea is currently being revived in several forms and it seems appropriate to include in this report a short account of some early unpublished results obtained with this method of planting. The idea of planting twin rows of potaotes spaced as close as 12 inches apart originated about 25 years ago, when the late Fred H. Bateman constructed a twin-row planter and cooperated in testing it in New Jersey, Virginia, and Maine. The results were obtained through the combined efforts of Dr. William Stuart, Mr. P. M. Lombard, Mr. B. E. Brown, Dr. William H. Martin and Mr. Fred H. Bateman.

The first trial was conducted in New Jersey in 1932 and from the results it was concluded that recommendations for the twin-row planting method were not warranted. In this experiment single-row plots receiving 2,000 pounds of fertilizer per acre yielded 118 bushels per acre U. S. No. 1 tubers, whereas comparable twin-row plots yielded only 112 bushels.

A similar experiment was repeated in 1933. All the yields were higher this year, but the twin-rows yielded either less than or the same as comparable single rows in all comparisons. Since the cost of seed for the twin rows was about twice that for single rows, there oviously was an economic loss. It was again concluded that the twin-row method of planting was not advantageous.

Similar experiments were conducted on Arlington Farm, Virginia, in 1932 and 1933. Different rates of fertilizer were used,ranging from 1,000 to 3,000 pounds per acre. After allowances were made for the different costs of fertilizer and seed, there were only three net increases for twin rows over single rows, ranging from $1.93 to $7.17 per acre, but there were 6 net losses, ranging from $2.12 to $35.13 per acre.

In the Maine experiment conducted in 1935 the average yield from the twin-row plots was only 3 bushels more potatoes per acre than that from comparable single-row plots, even though the amount of seed used on the twin-row plots was increased almost 100 per cent.

In seeking an explanation for these results one should not underestimate the effects of certain limiting factors which tend to exert increasing influence on production when plant populations exceed a certain plant density. These factors, such as leaf shading, competition for nutrients and moisture, and fungus disease spread all become more critical with broadleaf root crops like potatoes and sugar beets when plant densities are high. A plant density point is eventually reached where the yield-reducing effects of these factors exceed the increase obtained from greater plant density, thus causing a negative correlation between plant population and yield. Apparently the optimum plant density for greatest economic returns from potatoes was reached in these early trials without resorting to twin-row planting.

Another important point to be considered with twin-row planting is that it is practically impossible to ridge potatoes properly when they are planted in narrow rows. Many of the potatoes are apt to be without sufficient soil covering to prevent greening after the veins die or are killed with a vine killer.

Although early experience with the twin-row planting method has not been encouraging, this does not entirely rule out the possibility of obtaining more favorable results with this method when irrigation is used or in the case of seed potato production where tuber size and yield are considered equally important.

Does Band Placement of Fertilizer Restrict Root Growth?

Band placement of fertilizer is now used extensively on potatoes and the idea is being adapted to fertilizer application on other crops as well. Some potato workers, however, have been uncertain about the possibility that with band placement, root development may be so restricted to the fertilizer zone as to be a detriment to the crop during dry weather. This contention is worth examining because a number of physiological principles are involved, most of which tend to make such a possibility highly unlikely.

In the first place many field examinations of the roots of potato plants fertilized by the band method have never shown clear-cut evidence of such root growth restriction. To postulate, root growth of this type restricted to the fertilizer zone one must assume that growth-promoting materials are (1) synthesized in the root zone near the fertilizer or (2) translocated in greater amounts from the leaves to this specific root zone. From our knowledge of the arrangement of the vascular system of the plant and of plant metabolism, both of these assumptions must be rejected as being highly unlikely.

To carry the discussion further one need only remember that potatoes fertilized on one side only never grow lop-sided plants. The nutrients may be absorbed by only one set of roots but these nutrients are translocated to the leaves and used for the synthesis of growth-promoting materials

which are then re-translocated to all parts of the plant, much like the blood in the blood stream of the body.

Neither are roots attracted to the fertilizer zone in the soil. Strangely enough, although roots exhibit geotropism and hydrotropism, chemotropism has never been clearly demonstrated. As a matter of fact work with time-lapse photography has shown definitely that chemotropism is entirely lacking in roots.

Another point to consider is that much of the fertilizer, particularly the nitrogen and potash salts, is readily soluble so that in a short time there is a movement of these salt solutions into the soil above or below the band, depending on weather conditions. This movement tends to enlarge the fertilizer zone in the soil and also to reduce the fertilizer concentration.

Over the years band placement of fertilizer has generally given good results with potatoes most of the time. Where it has appeared to be less satisfactory one can be reasonably sure that restrictions of root growth from banded fertilizer was not the critical factor responsible.

Concluding Statement

These are but a few indications of the changes in theory and practice that are taking place in the field of potato nutrition. Collectively they indicate progress because only through an evaluation of new concepts and new approaches to old problems can research in potato nutrition be expected to rise above the high plateau it has reached. Future demands for potatoes as food and for industrial uses, without doubt, can be expected to provide an added incentive for a forward movement in potato nutritional research.

Respectfully submitted:

Dr. Arthur Hawkins — Dr. Richard L. Sawyer
Dr. O. A. Lorenz — Dr. L. M. Ware
Prof. N. R. Richards — Dr. G. V. C. Houghland, *Chairman*

REPORT OF THE MEMBERSHIP COMMITTEE - 1959

The total membership of The Potato Association of America at the date of the annual meeting at Fredericton, N. B., August 13, 1959, stands at 2253. This is approximately the same as that of the previous year with some of the reductions in a few states being equalized by additions from others.

About forty per cent of the total membership includes group members consisting primarily of potato growers in Maine, Michigan, California, New York, New Jersey and Washington.

In addition to the regular membership, the Association is proud to have 12 sustaining members.

It is anticipated that more research workers as well as growers will be made acquainted with the American Potato Journal and the Potato Association of America.

W. G. Hoyman — C. H. Dearborn
George Ayers — O. Turnquist, *Chairman*

Other Committee reports will appear in the November issue.

PICTURES OF ANNUAL MEETING

Prints of a set of 58 pictures taken at Fredericton Meetings are available: 50¢ for 5 x 7 and 75¢ for 8 x 10 plus 25¢ postage. A sample set of prints is being circulated; if you would like to see them or order prints write:

G. V. C. Houghland
4338 Clagett Road
Hyattsville, Maryland.